# The Effect of Guidance Systems on Civilian Casualty Ratios in Modern Conflicts

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

**Kieran Patrick Lynch**

Fall 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Kathryn A. Neeley, Associate Professor of STS, Department of Engineering and Society

# Introduction

Civilian casualties have existed as long as war has existed. Historically there was no attempt made to prevent civilian casualties, in fact sometimes they were an explicit goal to demoralize the defenders or opposing nation. There was also not the same distinction there is today between combatants and non-combatants i.e., civilians. A great example of both these issues colliding is in the medieval siege where townsfolk were expected to assist the defenders on the wall and the enemy responded in kind by lighting flaming arrows to force the townsfolk to put out the fires instead of focusing on the defense of the city (Petersen 2014).

The movement towards rules of war began defining civilians separately from soldiers and began affording them protections as most civilians could no longer be reasonably considered combatants or potential combatants by the 1800s if they lacked any weaponry. These rules were and are a reflection of the moral belief that civilians should not be targeted (Van Schaack 2023) (Petersen 2014).

Ranged weaponry has also become more and more accurate over time. Compare a medieval bow with a modern sniper rifle. Beyond small arms, new types of weapons have been created such as bombs which have become very accurate since their inception where friendly fire was a significant concern. Without doing any investigation one might assume that civilian casualties would fall as a result of the ability to be more accurate. This paper discusses the disconnect between this expectation and the reality that civilian casualties have not reduced when controlling for conflict size.

Civilian casualties in war are a perennial problem. In the second world war alone over 45 million civilians died. Civilian casualties have still been high in modern conflicts such as the Iraq

war. It is generally agreed that civilian casualties are not a good thing. Civilian casualties have been used as propaganda for the side who had civilian deaths. A prominent example of this being the “Rape of Belgium.” An example propaganda poster can be seen below. (Khorram-Manesh et al. 2021). This shows that people view civilian casualties and deaths in enough of a negative light to energize a population in favor of a war because civilian casualties are so abhorrent to people.

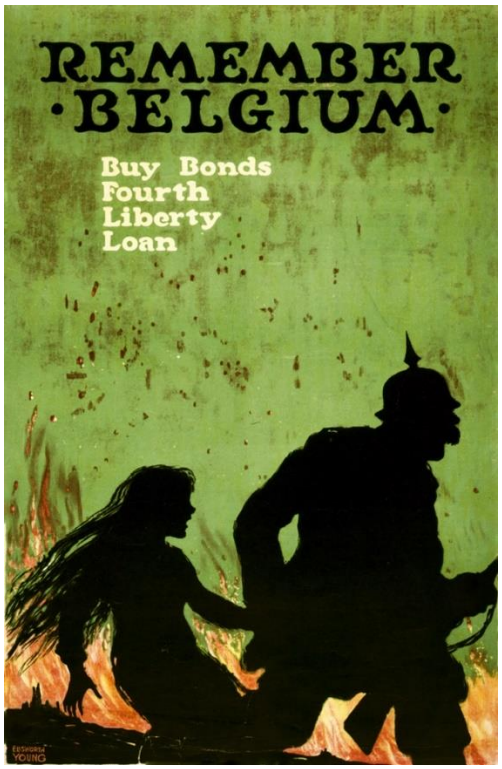


*Figure 1: Example Propaganda Poster (Young 1918)*

Intentional civilian deaths have been banned by international law since 1977 via a new Protocol I of the Geneva Conventions. However, the United States has not signed on to this only signing onto civilian rights in occupied territories, combat zones still being unregulated. The United States has historically not signed on to many regulations of warfare including some

articles of the Geneva conventions. Even without legal protection the United States generally does not engage in intentional civilian death (Aldrich 1991).

This could be due to differences in policy, but it could also be improved targeting as the bombs or missiles actually hit their intended targets instead of nearby civilians. Targeting systems first began to be used in the Second World War with the V2 rocket made by Werner von Braun. It was the first intercontinental ballistic missile and had flight times and covered distances that were too large to simply be precalculated or estimated (Tomayko 1985). Guidance has become a mainstay in defense with modern aircraft being armed with exclusively guided missiles only legacy systems like the B52 from the 1950s still use "dumb" bombs albeit the use has stopped recently (Philipps 2015). Various categories of missiles have been created to cope with the ever-increasing variety and guidance systems of new missiles (Siouris 2004, p. 1-13).

Precision munitions have become ubiquitous in modern warfare. Even legacy systems like the B-52 bomber which was designed in the 1950s were retrofitted to almost exclusively use "smart bombs", bomb that have at least some sort of guidance. According to Pickrell, the B-52s were given a new bomb deployment system called a CRL. He went on to state that "CRLs were delivered to the service in November 2017. Now each CRL allows for internal carriage, which adds an additional eight smart bombs per aircraft" which shows the military is very interested in expanding the usage of these smart munitions recently even on legacy systems. All modern systems have them built in when they are built because of the requirements of modern war (Pickrell 2019). These new more accurate weapon system are so ubiquitous it is impossible to discuss modern conflicts without discussing them.

These new targeting systems, despite their advantages in accuracy have ironically found it just as difficult to avoid civilian casualties. This was determined via analysis of ratios of civilian casualties to military rather than the naïve approach of absolute civilian casualties.

## Problem Definition

Civilian casualties have been falling as targeting systems have improved. The drop in civilian casualties can be seen in the chart below in Figure 1 which covers the US conflicts after the second World War (Khorram-Manesh et al. 2021). Likewise, targeting technology was first pioneered in World War II with simple guidance for the V2 rockets. These have improved to radar and infrared guided systems with great accuracy. These radar systems have become so integrated into modern combat that modern aircraft are designed from the ground up to be less visible to radar targeting systems (Siouris 2004 p. 1-13). Thus, a correlation between the drop in civilian casualties and improved guidance systems could be causal.

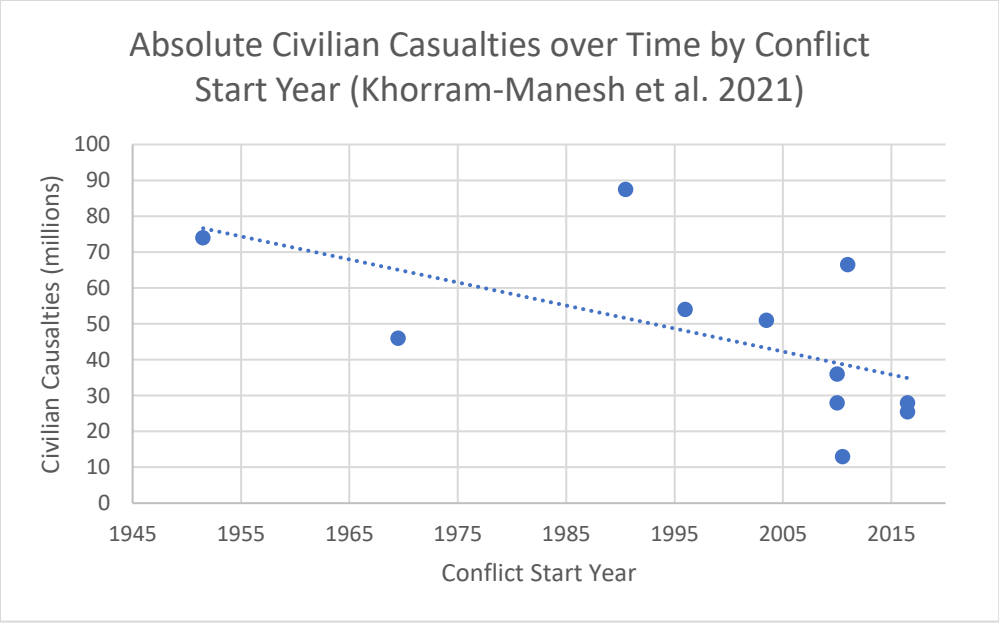


*Figure 2: Dropping Absolute Civilian Casualties over Time (Khorram-Manesh et al. 2021)*

However, absolute deaths as a measure for civilian casualties is not necessarily a good metric because deaths do not account for the total size of a conflict. Border skirmishes result in slim to no casualties because there is often only one battle generally not even near large civilian populations whereas the second world war took place across a continent with significant amounts of urban combat. Thus, the casualty ratio was developed comparing civilian deaths to military deaths. This still does not take into account the entirety of the conflict such as location but does help differentiate between a border skirmish and a full-scale war. Using civilian combat ratio, the numbers of civilian deaths actually seems to remain constant. As Khorram-Manesh et alia states about modern wars, "the number of civilian casualties will still be high and might be comparable with that of wars in the former Yugoslavia, and Syrian." This would imply that one of the fundamental premises of most argumentation is wrong (Eckhardt 1989) (Khorram-Manesh et al. 2021).

Another factor that prevents simple comparison of civilian deaths, whether by ratios or absolute numbers, is modern conflicts also have a very different character than older conflicts. Compare the second world war to the Iraq war or Afghanistan war. The second world war was a conflict between mostly evenly matched states whereas the Iraq and Afghanistan wars were a global superpower attempting to remove a regime from power and replace it with a democracy against a country that only took weeks for the formal government to capitulate. Thus, in modern conflicts there was significantly more guerilla warfare which has higher civilian risks as combatants are more likely to be surrounded by civilians compared to a traditional front of a war because of the proximity of the conflict to civilians.

A particularly notable issue is the fact that most of the modern wars that the US is involved in are civil wars which according to Eckhardt "were most frequent during these three

centuries, and they killed the most civilians (69%)" (Eckhardt 1989). This shows that we would expect casualties to increase regardless as the conflicts the US is engaging in are the most prone to civilian deaths even without US involvement. Thus, the fact that casualties are increasing is not necessarily an indicator of poor policy decisions and could be simply the changing nature of conflict.

Conflict has also changed in that wars are much more likely to have foreign involvement in at least some capacity. For example, US involvement in Syria was mostly support local forces such as the Kurds predominantly to prevent the rise of extremist groups such as ISIS. This involvement mostly was training local forces and providing other support, namely airstrikes. As will be discussed later, airstrikes are a particularly problematic form of support when it comes to civilian casualties.

These problems, particularly the fact that other militaries may not have coherent weapons policies which limits the generalizability of this result. Many comparable foreign militaries, e.g., NATO members, have not been involved in any conflicts in recent years which limits research on the effects of their policies and comparing them to US policy. These foreign policies may have insights into which strikes are the most risky and thus actually be able to reduce civilian death. However, they cannot be properly analyzed due to the lack of conflicts they were involved in.

Additionally, civilian casualties is also a very broad term. Civilian casualties include both civilian deaths and civilian injuries thus modern weapons could reduce civilian death but leave more civilians injured leaving the casualty number the same. This is a major limitation of this research as there could have been a decline in civilian death, but this would not have appeared in my results. This would make research into new guidance systems directly reduce civilian deaths.

## Why Are Civilian Deaths Constant

The main point of control the military has over civilian casualties is its policy towards allowing actions that would result in civilian deaths. Thus, this project focused on both the specific policy positions that may be the cause of this consistency.

Air campaigns, also a relatively new invention in war, were the largest source of civilian deaths by the United States armed forces in 2020. In fact, there was only one incident that resulted in a civilian death that was not the result of an air strike (Annual Report on Civilian Casualties, 2020). These air strikes are also becoming increasingly common due to the fact that the US is putting fewer troops on the ground and relying on local allies and airstrikes instead. Modern airstrikes almost always use some form of guidance (Pickrell 2019). Thus, there is a probable connection between any changes in civilian casualties being a result of changes in airstrikes and thus improved guidance systems and thus should be investigated further.

These new precision munitions are objectively more accurate, which should allow for strikes that miss civilians. Compare World War II where the "average accuracy for bombers in 1943 was 1,200 feet, as measured by the standard circular error probable" to the Gulf War where they "had an average accuracy of 10 feet" (Correll 2010). This is a drastic change over time, they could be off by 4 football fields in World War II and now you could not even get a first down by missing. This drastic change without changing civilian casualties implies there is another factor at play, namely policy causing the disconnect as accuracy has improved to a point where you can precisely hit a specific tank.

However, guidance systems are only useful insofar as the target that has been chosen to hit is accurate. Thus, even with super accurate modern weapons without intelligence on who or

what is where, or the decision-making apparatus caring or taking into account civilian deaths these improvements are useless. Thus, department policies on use of force and the types of munitions that are used for various risk levels are important to examine as they can affect levels of civilian victimization (Downes 2006).

Department of Defense policies specifically mention “precision munitions”, munitions which provide a greater level of accuracy than other munitions. These kinds of munitions are allowed to be used where other methods would not be. For example, the threat level can be lower when using these munitions (Chairman of the Joint Chiefs of Staff, 2012). This suggests that the department of defense believes that these munitions are less likely to cause civilian harm.

There is a growing isolationist movement in the US which will almost certainly have the unintended effect of reducing US caused civilian casualties. When the US supports a side of the conflict it is often through airstrikes which as discussed is the greatest source of civilian casualties. US involvement also likely expands the conflict as the US would provide more weaponry which allows for more conflict and more death. Even though US weaponry may be more accurate than the weapons that local forces were using previously there should be no expectation that this would result in fewer civilian casualties without policy changes done by local forces.

However, it is unclear whether the US exiting conflicts will result in overall fewer casualties as the US not being involved will likely not stop the war. Additionally, local forces that are being supported by the US may be hesitant to engage in intentional civilian attacks as the US would likely pull support from those organizations. These local organizations probably do not have a coherent policy of when to use weapons and how to reduce civilian casualties making tracking or reduction practically impossible. Additionally, US involvement may shorten the

length of the war by allowing one side to win quickly thus preventing a prolonged war with more casualties. Even, the US providing weaponry may be beneficial to civilians in a prolonged war as if the US were not involved local forces may be forced to use chemical or other banned weaponry if they feel they have no other weapons they can use. For these reasons, US involvement may have an overall effect of reducing civilian casualties but that remains to be investigated.

These changing policies combined with the fact that civilian deaths have, in fact not decreased when controlling for size of conflict, may imply that there is a general sense of an acceptable number of civilian deaths that has been constant over time. For example, precision munitions are allowed in situations where conventional weapons are not. In the past these strikes may have simply not been done. This does line up with other advances in technology such as average commute times always being approximately 30 minutes despite large growth in size of cities and transportation technology (Marchetti 1994). People simply choose to live further away in absolute distance as technology improved rather than have shorter commute times due to faster transportation. We are simply dropping more bombs in more situations because they are more accurate and leaving the casualty rate the same.

## Policy Reasons

If as we obtain more and more accurate weapons simply add the possibility to use those, we should not expect civilian casualties to decrease. For example, suppose a World War II era bomb has a chance of killing a civilian of 50% for any given strike whereas a modern weapon has a chance of 5%. If the policy guidelines allow for the old weapon to be used 1 out of 50 situations whereas the new weapons can be used in 1 out of every 5 situations, then we would

expect the number of casualties to be the same (assuming the same number of applicable situations). This is very analogous to the current policy guidelines regarding weapon use. The old weapons are still allowed to be used but simply at a much higher threshold e.g., 1 in every 50 scenarios, whereas the new weapons are allowed to be used in many other situations e.g., 1 in every 5 scenarios. Obviously, these numbers are very crude, but the point remains that we should not expect civilian casualties to decrease with our current way of implementing new weapons.

To actually reduce civilian deaths the threshold for ordering any strike must be increased. Continuing the previous example, the new precision munitions must take the role of the old weapons e.g., the new weapons can be used 1 in every 50 scenarios. The old weapons can have their threshold increased e.g., 1 in every 500 scenarios, or be retired entirely. This is the only way we would expect civilian casualties to decrease. This can be seen very nicely in the visualization below.

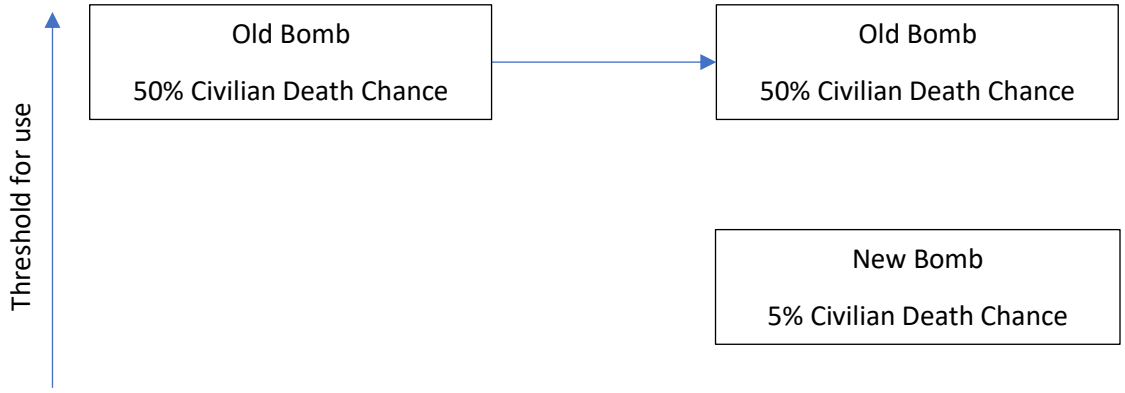


*Figure 3: Current System of Adding Weapons (own work)*

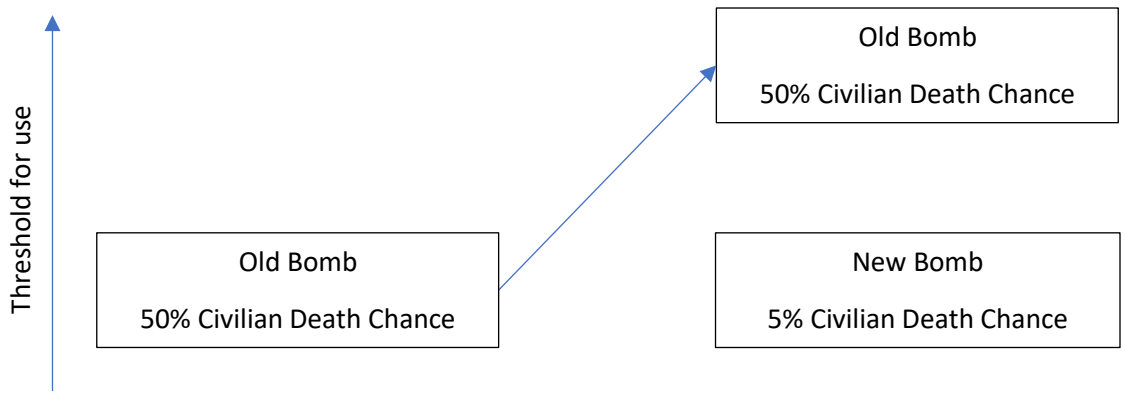


*Figure 4: What would be required to reduce civilian casualties (own work)*

Additionally, there is still the factor of a lack of political will which has no clear solution. Convincing people to change their position or be politically motivated on any social issue is a tall order and if someone had the solution the world would be significantly different very likely not positively.

Another possible reason for the lack of change is unwillingness of the modern American public to support "boots on the ground" or placing US soldiers in combat zones. According to Pew even shortly after the Iraq war began in 2007, "by 54% to 41%, more Americans favored bringing troops home from Iraq as soon as possible rather than keeping troops there until the situation had stabilized" (Pew 2023). This war was broadly supported and even early on Americans did not want more Americans to enter combat zones. This shows that the alternative to these airstrikes, soldiers in combat zones may be simply too politically unpopular.

This is further supported by the fact the military casualties precipitously dropped in recent wars compared to Korea and Vietnam. The military deaths in Korea were 36,574 and in Vietnam 58,209 compared to the Gulf war with 382 and 2,219 for Afghanistan. (Department of Defense 2023) (Fischer et al. 2007). There is a whole order of magnitude difference between modern war casualties compared to prior conflicts. This may only be possible due to the

increasing number of airstrikes which results in fewer Americans in combat. This difference would not appear in civilian casualty totals due to the fact that the military deaths are mostly not US soldiers but rather US supported local fighters particularly in Afghanistan. This shows a major possible reason why these policies exist, protecting American lives over civilians in combat areas that the US is involved in.

The combination of lack of public will and the potential effectiveness of these policy decision in reducing American deaths makes it unlikely for these policies to change even though they result in large numbers of civilian deaths as the American public is seemingly more concerned with American than any number of foreign deaths.

Further, it is not clear that a country's goal should be to prioritize reduction in civilian casualties at the expense of its own troops. Most people would support reducing civilian casualties in the abstract but if you add the condition that the reduction will increase the casualties of our own soldiers then support would likely drop precipitously. These two conflicting goals, preventing civilian casualties and reducing casualties of Americans, will likely prevent any significant change in at least the near term.

## Conclusion

With new focus on civilian casualties in the post-world war era many would initially assume that civilian casualties would decrease but they have not. This disconnect is not due to lack of technology but a lack of political will or understanding because either policymaker do not understand that ratios have not gone down or do and are not implementing changes that would reduce ratios. The changes that policy makers have made regarding these new more accurate weapons should never have been expected to reduce civilian casualties. There should be no

expectation that technology will "solve" civilian casualties as one may initially assume, because of these weapons have less propensity to miss and hit civilians, without major changes to how these weapons are implemented in policy.

There is still opportunity to increase the understanding of the area by exploring which strikes result in the greatest number of civilian casualties to attempt to mitigate civilian deaths without significantly reducing the overall number of strikes. This would allow the current advantages of these strike, reduced American troop deaths and American support, without as much of the major drawback, civilian casualties.

This paper provides a potential roadmap for better understanding civilian casualties if put in policymakers' hands. Focusing on absolute numbers of civilian casualties is not useful but rather one should focus on ratios of civilian deaths to military death However, even with this knowledge the odds of them following through with the knowledge that this paper delivers is still questionable due to potential costs of making these changes.

# References:


Aldrich, G. H. (1991). Prospects for United States ratification of additional Protocol I to the 1949 Geneva Conventions. *American Journal of International Law*, *85*(1), 1–20. https://doi.org/10.2307/2203556

Annual Report on Civilian Casualties In Connection With United States Military Operations in 2020. (2020). *Department of Defense*. https://int.nyt.com/data/documenttools/annual-report-civilian-casualties-2020/7d258e324d84d499/full.pdf

Chairman of the Joint Chiefs of Staff. (2012). No-Strike and the Collateral Damage Estimation Methodology. *Department of Defense*. https://info.publicintelligence.net/CJCS-CollateralDamage.pdf

Correll, J. (2010). The emergence of smart bombs - air force magazine. *Air & Space Forces Magazine*. https://www.airandspaceforces.com/PDF/MagazineArchive/Documents/2010/March%202010/0310bombs.pdf

Department of Defense. (2023). *Casualty Status* [Press release].

Downes, A. B. (2006). Desperate Times, Desperate Measures: The Causes of Civilian Victimization in War. *International Security*, *30*(4), 152–195. doi:10.1162/isec.2006.30.4.152

Eckhardt, W. (1989). Civilian deaths in wartime. *Bulletin of Peace Proposals*, *20*(1), 89–98. https://doi.org/10.1177/096701068902000108

Fischer, H., Klarman, K., & Oboroceanu, M.-J. (2007). *American War and Military Operations Casualties: List and Statistics*. https://crsreports.congress.gov/product/pdf/RL/RL32492

Khorram-Manesh, A., Burkle, F. M., Goniewicz, K., & Robinson, Y. (2021). Estimating the Number of Civilian Casualties in Modern Armed Conflicts–A Systematic Review. *Frontiers in Public Health*, 9. https://doi.org/10.3389/fpubh.2021.765261

Marchetti, C. (1994). Anthropological invariants in travel behavior. *Technological Forecasting and Social Change*, *47*(1), 75–88. https://doi.org/10.1016/0040-1625(94)90041-8

McNerney, M. J., Tarini, G., Sudkamp, K. M., Lewis, L., Grisé, M., & Moore, P. (2021). U.S. Department of Defense Civilian Casualty Policies and Procedures: An Independent Assessment. doi:10.7249/RR-A418-1

Petersen, I. B. (2014, October 13). Why do we spare civilians in war? *ScienceNordic*. https://www.sciencenordic.com/civilian-denmark-history/why-do-we-spare-civilians-in-war/1408411

Pickrell, R. (2022, August 17). B-52s are getting an upgrade that will let them drop smart bombs like never before. *Air Force Times*. https://www.airforcetimes.com/news/your-air-force/2019/03/03/b-52s-are-getting-an-upgrade-that-will-let-them-drop-smart-bombs-like-never-before/

Siouris, G. M. (2004). Missile guidance and control systems. *Applied Mechanics Reviews*, 57(6), 1-13. https://doi.org/10.1115/1.1849174

Van Schaack, B. (2022, April 22). *Siege warfare and the starvation of civilians as a weapon of war and war crime - just security*. Just Security. https://www.justsecurity.org/29157/siege-warfare-starvation-civilians-war-crime/

Young, E. (1918). *Remember Belgium*. https://commons.wikimedia.org/wiki/File:Remember_Belgium.jpg